

Calculus I factors women out of STEM degrees

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It's no secret that Calculus I is a major hurdle in the quest for a science degree. But, according to a new paper by Colorado State University researchers, the class is far more likely to discourage women than men from continuing on in their chosen field. How much more likely? One-and-a-half times. And it doesn't take a math degree to spot that as a serious imbalance.

The findings, published in *PLOS ONE*, suggest that a major factor in [women's](#) decision to leave a STEM (science, technology, engineering or math) path after Calculus I isn't ability, but confidence in their ability.

Both men and women experience a loss of confidence in their math skills at a similar rate in Calc I, says co-author Jess Ellis, an assistant professor of mathematics in the College of Natural Sciences. The problem, says co-author Bailey Fosdick, an assistant professor of statistics, is that women arrive with lower math confidence to begin with. "When women are leaving, it is because they don't think they can do it" - not because they can't do it - she says.

The study was a product of Ellis' graduate work on a larger investigation, funded by the National Science Foundation and backed by the Mathematical Association of America, of college-level calculus. Students across the country were asked about their interest in and intention to pursue a STEM degree, their test scores, preparation, learning experience, plans and backgrounds - before taking Calculus I and after. A student was considered to "persist" in the STEM track if they went on to take Calculus II.

The more time Ellis spent with the data, she says, "it seemed like there was a big issue with gender - it just kind of jumped out."

Of the [students](#) who switched out after Calculus I, when asked why they decided against taking

Calculus II, most of the possible explanations fell fairly equally across the genders (too many classes, not needed for major, etc.) - except for one: "I do not believe I understand the ideas of Calculus I well enough to take Calculus II." Of those who had been planning to major in a STEM area, 14 percent of men who switched out listed this as a reason; 35 percent of women did. But fewer than one in five of the departing students of either gender reported that their Calc I grade was actually too low to continue.

Of grads entering careers in STEM, only one quarter of them are women. However, interest at early ages is just about equal, with about two-thirds of fourth graders, male and female, stating an interest in science.

Closing this gap could help fill some major projected shortages in the U.S. workforce, note Ellis, Fosdick and their co-author Chris Rasmussen, a professor of math at San Diego State University. Over the next decade, there will be an estimated shortfall of about 1 million STEM workers compared to demand. One simple way to help fill that deficit would be to stop the female STEM student "pipeline leak" at the Calculus I juncture.

If the same percentage of women as men stuck with STEM after Calc I, the percentage of women entering the STEM workforce could be closer to 37 - rather than the current 25. Still not equal, but moving closer to parity. And there are lots of incentives. STEM jobs offer the highest starting salaries for college graduates, according to a 2016 report by the National Association of Colleges and Employers.

The findings offer opportunities for improvement. For one, the data showed that teaching quality did have an impact on all students' plans to stay in the field. Part of that could be better relating introductory calculus to students' chosen area.

"Students usually don't come into science saying, 'I want to study calculus!'" Fosdick says. They arrive on campus energized by experiences they had in high school biology or chemistry. And calculus often doesn't come into play in those disciplines until higher-level courses, she points out. This leaves students feeling like the pains of calculus won't have a payoff for them.

Another lesson is that supporting and encouraging students along the way is important. "In my classes, I try to do things to raise the confidence of all people in the class," Ellis says. Since completing the study, she says, she finds that she is now more attune to "trying to make sure women have a voice - and if they get something wrong once, to let them know that's good and not bad." In fact, she is now looking at foundational calculus classes in a completely different light: as an avenue to rebuild students' confidence in math.

In addition to focusing on students who intended to pursue a STEM degree, Ellis and Fosdick also see this wakeup call as a chance to bring more people into the field. Even for people who never intended to take Calculus II, a first college calculus class, if taught well, "could be an opportunity to have them leave not hating math, but actually to bring them in," Ellis says. And for those who continue in their chosen non-STEM field, whether business or social work, "having more people who are STEM- and calculus-literate would be great," she notes.

Ellis and Fosdick are now looking deeper into the data for trends of students from minority, lower socioeconomic status and first-generation backgrounds.

In the meantime, all students at CSU can get extra calculus support at the Department of Mathematics' new Calculus Center, opening this fall. It was inspired, in part, Ellis says, based on her and her colleagues' earlier research. "We are seeing changes at a lot of institutions." Which is exciting, she notes. Because for a career in STEM, [calculus](#) is integral.

Provided by Colorado State University

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